Signals Reflected Via Aircraft

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A Wideview View

In his article "Aircraft Enhancement Another View" (AR March 89) Ian Cowan VK1BG clearly explains that although he accepts the fact that VHF and UHF signals propagate beyond the horizon via reflections from aircraft he thinks that there is another propagation medium operating at the same time. His erudite theory contends that the heat generated by large jet aircraft in flight gives rise to a mini-inversion which in turn enables beyond the horizon propagation also.

Let's keep this idea in mind whilst we consider another aspect of reflections from aircraft which has received little attention up until now:

Slant Range

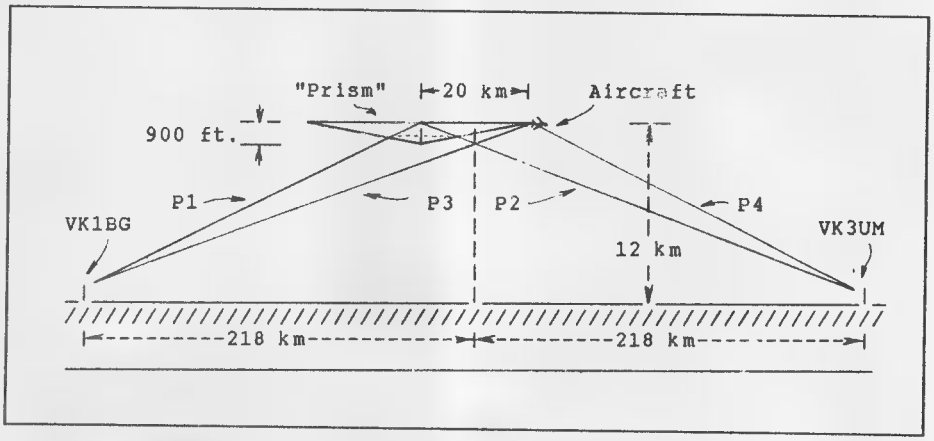
It is thought that the path length does not change during forward scatter contacts via aircraft reflections and that this is evidenced by the lack of Doppler shift, but this isn't quite true. It would be true only if the aircraft track exactly coincided with the line of sight path all the way from transmitter to receiver which is impossible in practice. The lack of noticeable Doppler is simply due to the fact that the range doesn't change by much.

To understand the significance of this we will examine the accompanying diagram. It represents a simplified profile of the VK1BG to VK3UM path complete with a Boeing 747 flying at about 39,000 feet trailing a VK1BG "prism" which is dutifully refracting the signal towards VK3UM at the same time as the aircraft is doing its bit by reflecting it. We take the distance between the two stations to be 436 km.

We note that the length of the signal path from VK1BG to VK3UM is equal to P1 + P2 via the refracting centre trailing the aircraft by 20 km and also P3 + P4 via reflection from the aircraft proper. Let's work out what these distances are. We will start with the aircraft and the prism centre equally spaced about the middle of the path as in the diagram and round the height off to an even 12km.

$$P1 + P2 = \sqrt{(208^2 + 12^2)} + \sqrt{(228^2 + 12^2)} = 436.66144 \text{ km}$$

$$P3 + P4 = \sqrt{(228^2 + 12^2)} + \sqrt{(208^2 + 12^2)} = 436.66144 \text{ km}$$



We observe that the two paths are equal in length. However the aircraft is travelling at 870 km per hour so what is the situation when it has moved say 2 km closer to Melbourne and VK3UM? Let's see:

$$P1 + P2 = \sqrt{(210^2 + 12^2)} + \sqrt{(226^2 + 12^2)} = 436.66094 \text{ km}$$

$$P3 + P4 = \sqrt{(230^2 + 12^2)} + \sqrt{(206^2 + 12^2)} = 436.66205 \text{ km}$$

We see that the paths now differ in length by 0.00111 km or 1.11 metres. Using the same method let's calculate the path differences for 2km increments in aircraft position for say 22km. The results are given in the accompanying table:

Aircraft position.	Path difference.
Start position	0.00 m
+ 2 km	1.11 m
+ 4 km	2.22 m
+ 6 km	3.34 m
+ 8 km	4.45 m
+ 10 km	5.58 m
+ 12 km	6.71 m
+ 14 km	7.85 m
+ 16 km	8.99 m
+ 18 km	10.14 m
+ 20 km	11.30 m
+ 22 km	12.48 m

We observe that the paths differ by increasing amounts as the aircraft heads towards VK3UM. If we wished we could work out that close to the point of descent into Melbourne the path difference would be several kilometres. We would also find that on Canberra side of our centre point start the paths differ in length in the same way as on the Melbourne side.

What bearing has all this got on the VK1BG theory? Let's see:

Interference And Phase

When a signal from a single transmitter is received via two (or more) paths the resultant signal is determined by the amplitudes and phase relationships of its component signals. We observe from the table that over 22 km the path length difference changed by 12.48 metres. This happens in about 91 seconds at 870 km/h.

Therefore a 432 MHz signal from VK3UM to VK1BG or vice versa will reinforce and cancel 36 times (every half wave length) or about every 2.5 seconds during this 22 km stretch of the aircraft's flight. It will get faster and faster as the aircraft gets nearer Melbourne!.

In other words the two path system will result in continuous "flutter" on the received signal. It should also be noted that changing the simplified dimensions that I used from the diagram won't change this simple fact. Furthermore any instability in that 20 km distance from the aircraft to the refraction centre in the "prism" will make things worse.

However if you use aircraft reflections you know that there is really no problem with continuous flutter throughout your contacts simply because it DOES NOT HAPPEN IN PRACTICE!

Now let's have another look at that VK1BG theory:

Another View?

VK1BG suggests that there are two (at least) means by which an aircraft enables beyond the horizon propagation at VHF and UHF but as we have demonstrated above this will result in continuous flutter throughout the entire contact and as we all know this does not happen in practice. The fact that the signals lack aircraft flutter clearly means that there is only one propagation path! Something's wrong here!

There is no doubt that signals are reflected off the aircraft proper, not even VK1BG disputes that, so where does this leave us?

Obviously there is only one answer: THE PROPAGATION PATH ENVISAGED BY VK1BG DOES NOT EXIST!

Instead of showing, as he says, that such a system does exist VK1BG has shown us that it is possible to put together a seemingly plausible sounding story to suggest that it MIGHT. He does not provide us with any reason for embarking on this line of speculation in the first place other than that he thinks my calculations (relating to signal strength) don't fit his observations and no evidence that he is cognisant with any of the considerable amount of published data relating to reflection of radio signals by aircraft extending back to early 1930s.

In short, he is asking us to believe in the existence of a propagation mechanism which countless experts have failed to detect, predict or even speculate upon during nearly 60 years (30 since the start of the big jet era) of observations in this specific area. I don't think his argument is that good. Do you?

Reflections From Aircraft

Reflection of radio signals by objects on the path between the transmitter and receiver is not new. It was noted in the early 1920s and was demonstrated as a method of detecting ships in 1922. Equipment specifically set up for this purpose was known as "wave interference" gear.

In the late 1930s radar systems were invented which used receivers and transmitters located at the same site so it became necessary to differentiate between them and the old wave interference gear which had the transmitters and receivers at different sites. Thus the terms "monostatic" for one site radars and "bistatic" for two (or more) site radars were born.

The system we use to communicate beyond the horizon by reflecting signals off aircraft is simple bistatic radar.

Bistatic Radar

Bistatic radar has characteristics which are quite different from those of monostatic radar and they are covered in detail in several text books and papers on the subject. These characteristics have a considerable bearing on our debate about aircraft reflections.

Therefore it should be mandatory for anyone thinking about punishing our credibility with their theories to make themselves familiar with the available information about bistatic radar before doing so.

One excellent source of information on the subject is "Introduction to Radar Systems" by Merril I Skolnik. It is available in a paperback edition for students.

Anyone who wishes to argue with me that the signals we see are not due to reflections from the aircraft proper had better have read Skolnik or some similar text first otherwise he will find me "forthright" in my views. I have better things to do.

Conclusion

VK1BG's theory has some parts which sound good but as every radioman worthy of the name knows you can't have two signal paths without interference and as there is no evidence of this the theory breaks down. ie: It's Wrong.

VK1BG is right about about one thing when he says that we will still be able to have "Aircraft Enhancement" contacts when aircraft are non metallic because to quote Skolnik:

"Another interesting property of forward scatter is that an absorbing body and a reflecting body of identical shape have the same forward scatter cross sections, but the backscattered energy from an absorbing body will be much less than that from a reflecting body. This follows from the application of Babinet's principle." (Babinet's principle is a law of optics).

Appendix

(1.) Multipath is sometimes seen near the beginning and end of contacts via aircraft reflections due to one of two possible mechanisms. The first is that some stations can hear the other weakly before the aircraft is in mutual view so that when it first appears (or is about to disappear) there is interference between the direct (tropo scatter) signal and the aircraft reflected one. This appears when the reflected signal assumes massive predominance due to the aircraft being in clear view of both stations.

The second is due to the interferometer effect known to satellite users and moon bouncers and is due to reflections from the earth when the signal source is near the horizon. This is only evident over the sea or flat terrain so is not likely to obtain on the Canberra-Melbourne path.

(2) Incidentally the advent of military aircraft with small radar cross sections may result in a resurgence of interest in bistatic radar since it may provide a more efficient means of detecting them than that afforded by monostatic radar.

(3) There is still a lot to be learnt about contacts via aircraft reflections. How can we estimate an aircraft's effective (Bistatic) reflecting area which seems to be greater than we first thought for example. This information would enable us to estimate in turn just how much power and aerial gain we would require in order to make the first contact between say Sydney and Melbourne on 1296 MHz using this mode. However we are not likely to find out about such things as soon as we might if we hadn't gone off on flights of fancy like that provided by the VK1BG theory.

Amateur radio lore already has its fair share of myths, furphys, half truths and plain nonsense without adding more.

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